here the physiography of the district was pointed out. After passing through the West Heath valley, in which a thin bed of water-bearing sand above the clay has produced a swamp, the party visited the residence of Mr. C. Evans, and inspected that gentleman's fine collection of Tertiary fossils.

THE new School of Science and the new Museum and Art Gallery at the rear of the Hartley Hall, Southampton, are fast approaching completion. There are two class rooms of about 20ft. by 16ft. 6in. and 16ft. high, and a large drawing-class room, 32ft. by 16ft. 6in. and 16ft. high. In the Art Gallery and Museum are two large rooms, 42ft. by 20ft., and about 18ft. high, lighted from the roof and connected with the Science School and the Art School.

A FREE Museum has lately been opened at Nottingham in Wheeler-Gate. The greater portion of the objects of interest which are in the museum, now the property of the town, originally belonged to the Nottingham Naturalists' Society, and a considerable number of valuable objects were added from time to time until the museum assumed its present dimensions.

ACCORDING to the Stockholm *Aftonbladet* an important discovery has been made in Sweden. An extensive coal-bed of remarkable depth and excellent quality has been struck near Raus, in Schonen. An enterprising company formed some time ago was encouraged by promising geological indications to institute borings, but the first results were hardly satisfactory. At a depth of 566ft. eleven strata of coal had indeed been pierced, but none of these exceeded in depth $1\frac{1}{4}$ft. Five feet farther down, however, a bed was struck with a thickness of $8\frac{3}{4}$ft. The borings have been continued, and are believed to prove satisfactorily the existence of an extensive coal-bed.

A MOST violent cyclone occurred at Madras on May 1. Many vessels were driven on shore, and completely wrecked. The pier has been again breached, and great damage done to the city and suburbs. On Friday, the 3rd, the storm was slightly abating.

AT a recent sitting of the French Academy a letter was read from the French Consular agent at Mostar on the earthquakes felt throughout the Herzegovina during the months of February and March last. The first was felt on the 6th of February, two days after the great aurora borealis. Other oscillations followed on the 7th and 8th, apparently in a N.W. and S.E. direction On the 13th a longer shock was experienced, followed by a loud rumbling sound like distant cannon. On the 25th and 27th stronger shocks, accompanied by noise, were felt, making about forty since the 6th. On March 2 and 3 the manifestations increased in intensity; but neither Ragusa nor Serajevo, so subject to earthquakes, appear to have been at all affected all the time.

SOME time in the summer of 1871 it was stated that Mr. Octave Pavé, a young Louisiana Frenchman, had started toward the North Pole by way of Siberia and Wrangell's Land, and that, in the absence of news from him, the assistance of the Siberian Government had been invoked, in consequence of grave fears for his safety. It now appears that he has not yet started on his mission, but is to sail from San Francisco in May for Kamschatka, where he will take in supplies, and proceed to Cape Yakan, on the north-east coast of Siberia. Here the vessel is to be abandoned, and a further exploration attempted on an India-rubber raft, composed of four rubber cylinders fastened together on the decks by wooden slats, to which the masts and rigging are attached. It is intended to head, after leaving Cape Yakan, for Wrangell's Land, a large island discovered by Captain Long in 1867. This being reached, the island is to be crossed on sledges; and if an open sea occur beyond, he is to take the raft again, and endeavour to sail to Greenland or Spitzbergen. The entire enterprise is conducted at the expense of the traveller; and however hazardous or chimerical the plan may be, we cannot but wish him success in his movements.

HISTORY OF THE NAMES CAMBRIAN AND SILURIAN IN GEOLOGY*

(*Continued from page* 17)

WHAT then was the value and the significance of the Silurian sections of Murchison, when examined in the light of the results of the Government surveyors? The Llandeilo rocks, having throughout the characteristic *Orthis* so much insisted upon by Murchison, were shown to be the base of a great conformable series, and to the eastward, in Shropshire, to rest on the upturned edges of the Longmynd rocks; while westward, near Bala, they overlie unconformably the Lingula-flags, and in the island of Anglesea repose directly upon the ancient crystalline schists. According to the author of the "Silurian System," there existed beneath the base of the Llandeilo formation a great conformable series of slaty rocks into which this formation passed, and from which it could not be distinguished either zoologically, stratigraphically, or lithologically. The sequence, determined from what were considered typical sections in the valley of the Towey in Caermarthenshire, as given by Murchison, for several years both before and after the publication of his work, was as follows:—1. Cambrian; 2. Llandeilo flags; 3. Caradoc sandstone; 4. Wenlock and Ludlow beds; 5. Old Red sandstone; the order being from north-west to south-east. What then were these fossiliferous Cambrian beds underlying the Llandeilo and indistinguishable from it? Sedgwick, with the aid of the Government surveyors, has answered the question in a manner which is well illustrated in his ideal section across the valley of the Towey. The whole of the Bala or Caradoc group rises in undulations to the north-west, while the Llandeilo flags at its base appear on an anticlinal in the valley, and are succeeded to the south-east by a portion of the Bala. The great mass of this group on the south-east side of the anticlinal is however concealed by the overlapping May Hill sandstone—the base of the unconformable upper series which includes the Wenlock and Ludlow beds. (Philos. Mag. IV. viii. 488.) The section to the south-east, commencing from the Llandeilo flags on the anticlinal, was made by Murchison the Silurian system, while the great mass of strata on the north-west side of the Llandeilo (which is the complete representative of the Caradoc or Bala beds, partially concealed on the south-west side) was supposed by him to lie beneath the Llandeilo, and was called Cambrian (the Upper Cambrian of Sedgwick). These rocks, with the Llandeilo at their base, were in fact identical with the Bala group studied by the latter in North Wales, and are now clearly traced through all the intermediate distance. This is admitted by Murchison, who says:—"The first rectification of this erroneous view was made in 1842 by Prof. Ramsay, who observed that instead of being succeeded by lower rocks to the north and west, the Llandeilo flags folded over in those directions, and passed under superior strata, charged with fossils which Mr. Salter recognised as well-known types of the Caradoc or Bala beds." ("Siluria," 4th ed., p. 57, foot-note.)

The true order of succession in South Wales was in fact:—1. Llandeilo; 2. Cambrian (=Caradoc or Bala); 3. Wenlock and Ludlow; 4. Old Red sandstone; the Caradoc or Bala beds being repeated on the two sides of the anticlinal, but in great part concealed on the south-east side by the overlapping May Hill or Upper Llandovery rocks. These latter, as has been shown, form the true base of the upper series which, in the Silurian sections, was represented by the Wenlock and Ludlow. Murchison had, by a strange oversight, completely inverted the order of his lower series, and turned the inferior members upside down. In fact, the Llandeilo flags, instead of being, as he had maintained, superior to the Cambrian (Caradoc or Bala) beds, were really inferior to them, and were only made Silurian by a great mistake. The Caradoc, under different names, was thus made to do duty at two horizons in the Silurian system, both below and above the Llandeilo flags. Nor was this all; for by another error, as we have seen, the Caradoc in the latter position was made to include the Pentamerus beds of the unconformably overlying series. Thus it clearly appears that, with the exception of the relations of the Wenlock and Ludlow beds to each other and to the overlying Old Red sandstone, which were correctly determined, the Silurian system of Murchison was altogether incorrect, and was moreover based upon a series of stratigraphical mistakes, which are scarcely paralleled in the history of geological investigation.

It was thus that the Lower Silurian was imposed on the scientific world; and we may as well ask with Sedgwick, whether geologists "would have accepted the Lower Silurian classification and nomenclature, had they known that the physical or sectional evidence upon which it was based had been from the first positively misunderstood." Feeling that his own sections were, as has since been fully established, free from error, Sedgwick naturally thought his name of Upper Cambrian should prevail for the great Bala group. Hence the long and embittered discussion that followed, in which Murchison in many respects occupied a position of vantage as against the Cambridge professor, and finally saw his name of Lower Silurian supplant almost entirely that of Upper Cambrian given by Sedgwick, who had first rightly defined and interpreted the geological relations of the group.

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* Reprinted from advance sheets of the *Canadian Naturalist*.

In a paper read before the Geological Society in June, 1843 (Proc. Geol. Soc. iv. 212-223), when the perplexity in which the relations of the Upper Cambrian and Silurian rocks were involved had not been cleared up by the discovery of Murchison's errors in stratigraphy, Sedgwick proposed a compromise, according to which the strata from the Bala limestone to the base of the Wenlock were to take the name of Cambro-Silurian; while that of Silurian should be reserved for the Wenlock and Ludlow beds, and for those below the Bala the name of Cambrian should be retained. The Festiniog group (including what were subsequently named the Lingula flags and the Tremadoc slates) would thus be Upper instead of Middle Cambrian, the original Upper Cambrian being henceforth Cambro-Silurian; it being understood that, wherever the dividing line might be drawn, all the groups above it should be called Cambro-Silurian, and all those below it Cambrian. This compromise was rejected by Murchison, who in the map accompanying the first edition of his "Siluria," in 1854, extended the Lower Silurian colour so as to include all but the lowest division of the Cambrian, viz., the Bangor group. When, however, the relations of Upper Cambrian and Silurian were made known by the discoveries of Sedgwick and the Government surveyors, this compromise was seen to be uncalled for, and was withdrawn in 1854 by Sedgwick, who re-claimed the name of Upper Cambrian for his Bala group.

In June 1843, Sedgwick proposed that the whole of the fossiliferous rocks below the horizon of the Wenlock should be designated Protozoic, and on Nov. 29, 1843, presented to the Geological Society an elaborate paper on the Older Palæozoic (Protozoic) Rocks of North Wales, with a coloured geological map. This paper, which embodied the results of the researches of Sedgwick and Salter, was not, however, published at length, but an abstract of it was prepared by Mr. Warburton, then president of the society, with a reduced copy of the map (Proc. Geol. Soc. iv. 212 and 251-268; also Geol. Jour. i. 5-22). In this map of Sedgwick's three divisions were established, viz., the hypozoic crystalline schists of Caernarvonshire, the Protozoic, and the Silurian. On the legend of the reduced map, as published by the Geological Society, these latter names were altered so as to read "Lower Silurian (Protozoic)" and "Upper Silurian." These changes, in conformity with the nomenclature of Murchison, were, it is unnecessary to say, made without the knowledge of Sedgwick, who did not inspect the reduced and altered map until it was appealed to as an evidence that he had abandoned his former ground, and had recognised the equivalency of the whole of his Cambrian with the Lower Silurian of Murchison. The reader will sympathise with the indignation with which Sedgwick declares that his map was "most unwarrantably tampered with," and will, moreover, learn with surprise that an inspection of the proof sheets of Warburton's abstract of Sedgwick's paper was refused him, notwithstanding his repeated solicitations. The story of all this, and finally of the refusal to print in the pages of the *Geological Journal* the reclamations of the venerable and aggrieved author, make altogether a painful chapter, which will be found in the *Philos. Magazine* for 1854 (IV. viii. pp. 301-317, 359-370, and 483-506), and more fully in the "Synopsis of British Palæozoic Rocks," which forms the introduction to McCoy's "British Palæozoic Fossils."

In connection with this history it may be mentioned that in March 1845 Sedgwick presented to the Geological Society a paper on the Comparative Classification of the Fossiliferous Rocks of North Wales and those of Cumberland, Westmoreland, and Lancashire, which appears also in abstract in the same volume of the *Geological Journal* that contains the abstract of the essay and the map just referred to (i. 442). That this abstract also is made by another than the author is evident from such an expression as "the author's opinion seems to be grounded on the following facts," &c. (p. 448), and from the manner in which the terms Lower and Upper Silurian are applied to certain fossiliferous rocks in Cumberland. Yet the words of this abstract are quoted with emphasis in "Siluria" (1st ed., 147), as if they were Sedgwick's own language, recognising Murchison's Silurian nomenclature.

II.—*Middle and Lower Cambrian*

Investigations in continental Europe were, meanwhile, preparing the way for a new chapter in the history of the lower palæozoic rocks. A series of sedimentary beds in Sweden and Norway had long been known to abound in singular petrifications, some of which had been examined by Linnæus, who gave to them the name of *Entomolithi*. They were also studied and described by Wahlenberg and by Brongniart, the latter of whom, from two varieties of the *Entomolithus paradoxus*, Linn, established in 1822 two genera, *Paradoxides* and *Agnostus*. In 1826 appeared a memoir by Dalman on the Palæadæ, or so-called Trilobites; which was followed, in 1828, by his classic work on the same subject ("Ueber die Palæaden oder so-genannten Trilobiten," 4to, with six plates, Leipsic). In these works were described and figured, among many others, two genera—*Olenus*, which included *Paradoxides* Brongn. and *Battus*, including *Agnostus* of the same author. Meanwhile, Hisinger was carefully studying the strata in which these Trilobites were found in Gothland, and in the same year (1828) published in his *Anteckningar*, or Notes on the Physical and Geognostical Structure of Norway and Sweden, a coloured geological map and section of these rocks as they occur in the county of Skaraborg, where three small circumscribed areas of nearly horizontal fossiliferous strata are shown to rest upon a floor of old crystalline rocks, in some parts granitic and in other gneissic in character. The section and map, as given by Hisinger, show the succession in the principal area to be as follows, in ascending order: (1) granite or gneiss, (2) sandstone, (3) alum-slates, (5) orthoceratite limestones, (4) clay, slates. By a curious oversight the colours on the legend are wrongly arranged and wrongly numbered, as above; for in the map and section it is made clear that the succession is that just given, and that the clay-slates (4) instead of being below, are above the orthoceratite-limestones (5).

In 1837 Hisinger published his great work on the organic remains of Sweden, entitled *Lethæa Suecica* (4to, with forty-two plates). In this he gives a tabular view, in descending order, of the rock-formations, and of the various genera and species described. The rocks of the areas just noticed appear in his fourth or lowest division, under the head of *Formationes Transitionis*, and are divided as follows:—

a. Strata calcarea recentiora Gottlandiæ.
b. Strata schisti argillacei.
c. Strata schisti aluminaris.
d. Strata calcarea antiquiora.
e. Strata saxi arenacei.

The succession thus given was however erroneous, and probably, like the mistake in the legend of the same author's map just mentioned, the result of inadvertence, the true position of the alum-slates (*c*) being between the older limestone (*d*) and the basal sandstone (*e*). This is shown both by Hisinger's map of 1828, and by the testimony of subsequent observers. In Murchison's work on the Geology of Russia in Europe, published in 1845, there is given (p. 15 *et seq.*) an account of his visit to this region in company with Prof. Loven, of Christiania; which, with figures of the sections, is reproduced in the different editions of "Siluria." The hill of Kinnekulle, on Lake Wener, is one of the three areas of transition rocks delineated on the mad of Hisinger above referred to. Resting upon a flat region of nearly vertical gneissic strata, we have according to Murchison, (1) a fucoidal sandstone, (2) alum-slates, (3) red orthoceratite limestone, (4) black graptolitic slates, the whole series being little over 1,000 ft. in thickness, and capped by erupted greenstone. Above these higher slates there are found in some parts of Gothland, other limestones with orthoceratites, trilobites, and corals, the newer limestone strata (*a*) of Hisinger; the whole overlain by thin sandstone beds. These higher limestones and sandstones contain the fauna of the Wenlock and Ludlow of England; while the lower limestones and graptolitic slates afford *Calymene Blumenbachii*, *Orthis calligramma*, and many other species common to the Bala group of North Wales. The alum-slates below these however contained, according to Hisinger, none of the species then known in British rocks, but in their stead five species of *Olenus* and two of *Battus* (*Agnostus*).

In 1854 Angelin published his *Palæontolologica Scandinavica*, part 1, *Crustacea formationis transitionis* (4to, forty-one plates), in which he divided the series of transition rocks above described by Hisinger into eight parts designated by Roman numerals, counting from the base. Of these I. was named *Regio Fucoidarum*, no organic remains other than fucoids being known therein; while the remaining seven were named from their characteristic genera of trilobites, which were as follows, in ascending order; certain letters being also used to designate the parts:—II. (A) Olenus: III. (B) Conocoryphe; IV. (BC) Ceratopyge; V. (C) Asaphus; VI. (D) Trinucleus; VII. (DE) Harpes; VIII. (E) Cryptonymus. In the *Regio Olenorum* (II.) was found also the allied genus *Paradoxides*. With regard to the characteristic genus of Regio III., the name of *Conocoryphe* was proposed for it by Corda in 1847, as synonymous with Zenker's name of *Conocephalus* (*Conocephalites*), already appropriated to a genus of insects.

Meanwhile the similar crustaceans which abound in the transition rocks of Bohemia had been studied and described by Hawle, Corda, and Beyrich, when Barrande began his admirable investigations of this ancient fauna and of its stratigraphical relations. He soon found that beneath the horizon characterised by fossils of the Bala group (Llandeilo and Caradoc) there existed in Bohemia a series of strata distinguished by a remarkable fauna, entirely distinct from anything known in Great Britain, but closely allied to that of the alum-slates of Scandinavia, corresponding to Regiones II. and III. of Angelin. To this he gave the name of the first or primordial fauna, and to the rocks yielding it that of the Primordial Zone. Resting upon the old gneisses of Bohemia appears a series of crystalline schists designated by Barrande as *Etage A*, overlain by a series of sandstones and conglomerates, *Etage B*, upon which repose the fossiliferous argillites of the Primordial Zone or *Etage C*. The rocks of the Etages A and B were by Barrande regarded as azoic, but in 1861, Fritsch of Prague, after a careful search, discovered in certain thin-bedded sandstones of B the traces of filled-up vertical double tubes; which, according to Salter (Mem. Geol. Sur. iii. 243), are probably the marks of annelides, and are identical with those found in the rocks of the Bangor or Longmynd group in Great Britain; which will be shown to belong to the Primordial Zone. It is, therefore, probable that the Etage B, which apparently corresponds to the Regio Fucoidarum or basal sandstone of Scandinavia, should itself be included in the Primordial Zone. It may here be noticed that it is in the crystalline schists of A that Gümbel has found *Eozoön bavaricum*. To the Etage C in Bohemia, Barrande assigns a thickness of about 1,200 feet, and to this his first fauna is confined, while in the succeeding divisions he distinguished a second and a third. The second fauna, which characterises Etage D, corresponds to that of the Bala group; while the third fauna, belonging to the Etages E, F, G, and H, is that of the May Hill, Wenlock, and Ludlow formations of Great Britain.

This classification of the ancient Bohemian faunas was first set forth by Barrande in 1846, in his *Notice Préliminaire*, in which he declared that the first fauna was below the base of the Llandeilo of Murchison, unknown in Great Britain, and, moreover, "new and independent in relation to the two Silurian faunas (his second and third) already established in England." This opinion he reiterated in 1859. These three divisions form in Bohemia an apparently continuous series, and being connected with each other by some common species, Barrande was led to look upon the whole as forming a single stratigraphical system; and finally to assert that these three independent faunas "form by their union an indivisible triad which is the Silurian system." (Bul. Soc. Geol. de Fr. II. xvi. 529-545.) Already, in 1852, in his magnificent work on the Silurian System of Bohemia, Barrande had given to the strata characterised by his first fauna the name of Primordial Silurian. It is difficult to assign any just reason for thus annexing to the Silurian—already augmented by the whole Upper Cambrian or Bala group of Sedgwick, (Llandeilo and Caradoc)—a great series of fossiliferous rocks lying below the base of the Llandeilo, and unsuspected by the author of the Silurian system; who persistently claimed the Llandeilo beds, with their characteristic second fauna, as marking the dawn of organic life.

Up to this time the primordial palæozoic fauna of Bohemia and of Scandinavia was, as we have said, unknown in Great Britain. The few organic remains mentioned by Sedgwick in 1835 as occurring in the region occupied by his Lower and Middle Cambrian, on Snowdon, were found to belong to Bala beds, which there rest upon the older rocks; nor was it until 1845 that Mr. Davis found in the Middle Cambrian remains of *Lingula*. In 1846, Sedgwick, in company with Mr. Davis, re-examined these rocks, and in December of the same year described the Lingula beds as overlaid by the Tremadoc slates and occupying a well-defined horizon in Caernarvon and Merionethshire, beneath the great mass of the Upper Cambrian rocks. (Geol. Jour. ii. 75, iii. 139.) Sedgwick, at the same time, noticed about this horizon certain Graptolites and an *Asaphus*, which were supposed to belong to the Tremadoc slates, but have since been declared by Salter to pertain to the Arenig or Lower Llandeilo beds, the base of the Upper Cambrian. (Mem. Geol. Sur. iii. 257, and Decade II.)

This discovery of the Lingula flags, as they were then named, and the fixing by Sedgwick of their geological horizon, was at once followed by a careful examination of them by the Government surveyors; and in 1847, Selwyn detected in the Lingula flags, near Dolgelly, in Merionethshire, the remains of two crustacean forms, the one a phyllopod, which has received the name of *Hymenocaris vermicauda* Salter, and the other a trilobite, which was described by Salter in 1849 as *Olenus micrurus*. (Geol. Survey, Decade II.) A species of *Paradoxides*, apparently identical with *P. Forchammeri* of Sweden, was also about this time recognised among specimens supposed to be from the same horizon. It has since been described as *P. Hicksii*, and found to belong to the basal beds of the Lingula flags—the Menevian group.

Upon the flanks of the Malvern Hills there are found resting upon the ancient crystalline rocks of the region, and overlain by the Pentamerus beds of the May Hill sandstone (originally called Caradoc by Murchison) a series of fossiliferous beds. These consist in their lowest part of about 600 feet of greenish sandstone, which have since yielded an *Obolella* and *Serpulites*, and are overlain by 500 feet of black schists. In these, in 1842, Prof. John Phillips found the remains of trilobites, which he subsequently described, in 1848, as three species of *Olenus* (Mem. Geol. Survey ii. part 1, 55). These black shales, which had not at that time furnished any organic remains, were by Murchison in his "Silurian System" (p. 416) in 1839 compared to the supposed passage beds in Caermarthenshire between the Llandeilo and the Cambrian (Bala) rocks; which, as we have seen, were newer and not older strata than the Llandeilo flags. From their lithological characters, and their relations to the Pentamerus beds, these lower fossiliferous strata of Malvern were subsequently referred by the Government geologists to the horizon of the Caradoc proper or Bala group; nor was it until 1851 that their true geological age and significance were made known. In that year, Barrande, fresh from the study of the older rocks of the Continent, came to England for the purpose of comparing the British fossils with those of the Primordial Zone which he had established in Bohemia and Scandinavia, and which he at once recognised in the Lingula flags of Sedgwick and in the black schists at Malvern; both of which were characterised by the presence of the genus *Olenus*, and were referred to the horizon of his Etage C. This important conclusion was announced by Salter to the British Association at Belfast in 1852 (Rep. Brit. Assoc., abstracts, p. 56, and Bull. Soc. Geol. de Fr. II. xvi. 537). Since that time the progress of investigation in the Middle and Lower Cambrian rocks of Wales has shown a fauna the importance and richness of which has increased from year to year.

The palæontological studies of Salter, while they confirmed the primordial character of the whole of the great mass of strata which make up the Middle Cambrian or Festiniog group of Sedgwick (consisting of the Lingula flags and the Tremadoc slates), led him to propose several sub-divisions. Thus he distinguished on palæontological grounds between the upper and lower Tremadoc slates, and for like reasons divided the Lingula flags into a lower and an upper portion. For the discussion of these distinctions the reader is referred to the memoirs of the Geol. Survey (iii. 240-257). Subsequent researches led to the division of the original Lingula flags into three parts, an upper and a middle, to which the names of Dolgelly and Maentwrog were given by Mr. Belt, and a third consisting of the basal beds, which were separated in 1865 by Salter and Hicks, with the designation of Menevian, derived from the ancient Roman name of St. David's in Pembrokeshire. It was here that in 1862, Salter found *Paradoxides* with *Agnostus* and *Lingula* in fine black shales at the base of the Lingula flags, resting conformably on the green and purple grits of the Lower Cambrian or Harlech beds. The locality was afterwards carefully studied by Hicks, and it was soon made apparent that the genus *Paradoxides*, both here and in North Wales, was confined to a horizon below the great mass of the Lingula flags, which, on the contrary, are characterised by numerous species of *Olenus*. These lower or Menevian beds are hence regarded by Salter as equivalent to the lowest portion of the Etage C of Barrande.

Beneath these Menevian beds there lies, in apparent conformity, the great Lower Cambrian series, frequently called the bottom or basement rocks by the Government surveyors; represented in North Wales by the Harlech grits, and in South Wales, near St. David's, by a similar series of green and purple sandstones, considered by Murchison and by others as the equivalent of the Harlech rocks. They were still supposed to be unfossiliferous until, in June 1867, Salter and Hicks announced the discovery in the red beds of this lower series, at St. David's, of a *Lingulella*, very like *L. ferruginea* of the Menevian (Geol. Jour. xxiii. 339; Siluria, 4th ed. 550). This led to a further examination of these Lower Cambrian beds, which has resulted in the discovery in them of a fauna distinctly primordial in type, and linked by the presence of several identical fossils to the Menevian; but in many respects distinct, and marking a lower fossiliferous horizon than anything known in Bohemia or in Scandinavia.

The first announcement of these important results was made to the British Association at Norwich in 1868. Further details were, however, laid before the Geological Society in May 1871 by Messrs. Harkness and Hicks, whose paper on the Ancient Rocks of St. David's Promontory appears in the Geological Journal for November 1871 (xxviii. 384). The Cambrian sediments here rest upon an older series of crystalline stratified rocks, described by the geological surveyors as syenite and greenstone, and having a north-west strike. Lying unconformably upon these, and with a north-east strike, we have the following series, in ascending order:—1, quartzose conglomerate, 60ft.; 2, greenish flaggy sandstone, 460ft.; 3, red flags or slaty beds, 50ft., containing *Lingulella ferruginea*, besides a larger species, *Discina*, and *Leperditia cambrensis*; 4, purple and greenish sandstones, 1,000ft.; 5, yellowish gray sandstones, flags and shales, 150ft., with *Plutonia*, *Conocoryphe*, *Microdiscus*, *Agnostus*, *Theca*, and *Protospongia*; 6, gray, purple and red flaggy sandstones, with most of the above genera, 1,500ft.; 7, gray flaggy beds, 150ft., with *Paradoxides*; 8, true Menevian beds, richly fossiliferous, 500ft. The latter are the probable equivalent of the base of Barrande's Etage C, and at St. David's are conformably overlain by the Lingula flags, beneath which we have, including the Menevian, a conformable series of 3,370ft. of uncrystalline sediments, fossiliferous nearly to the base, and holding a well-marked fauna distinct from anything hitherto known in Great Britain or elsewhere.

The Menevian beds are connected with the underlying strata by the presence of *Lingulella ferruginea*, *Discina pileolus*, and *Obolella sagittatus*, which extend through the whole series; and also by the genus *Paradoxides*, four species of which occur in the lower strata, from which the genus *Olenus*, which characterises the Lingula flags, seems to be absent. To a large tuberculated trilobite of a new genus found in these lowest rocks the name of *Plutonia Sedgwickii* has been given. Hicks has proposed to unite the Menevian with the Harlech beds, and to make the summit of the former the dividing line between the Lower and Middle Cambrian, a suggestion which has been adopted by Lyell. (Proc. Brit. Assoc. for 1868, p. 68, and Lyell, Student's Mannal of Geology, 466—469.)

Both Phillips and Lyell give the name of Upper Cambrian to the Lingula flags and the Tremadoc slates, which together constitute the Middle Cambrian of Sedgwick, and concede the title of Lower Silurian to the Bala group or Upper Cambrian of Sedgwick. The same view is adopted by Linnarsson in Sweden, who places the line between Cambrian and Silurian at the base of the Llandeilo or the second fauna. It was by following these authorities that I, inadvertently, in my address to the American Association for the Advancement of Science in August 1871, gave this horizon as the original division between Cambrian and Silurian. The reader of the first part of this paper will see with how much justice Sedgwick claims for the Cambrian the whole of the fossiliferous rocks of Wales beneath the base of the May Hill sandstone, including both the first and the second fauna. I cannot but agree with the late Henry Darwin Rogers, who, in 1856, reserved the designation of "the true European Silurian" for the rocks *above* this horizon. (Keith Johnston's Physical Atlas, 2nd ed.)

T. STERRY HUNT

(*To be continued*)

ACOUSTICAL EXPERIMENTS*

SHOWING THAT THE TRANSLATION OF A VIBRATING BODY CAUSES IT TO GIVE A WAVE-LENGTH DIFFERING FROM THAT PRODUCED BY THE SAME VIBRATING BODY WHEN STATIONARY

The Apparatus

FOUR tuning-forks mounted on resonant cases and giving the note UT^3, = 256 complete vibrations per second, were obtained. I will designate them as Nos. 1, 2, 3, and 4.

Nos. 1 and 2 were brought into perfect unison by a process to be described.

No. 1 was placed before a lantern, and just touching one of its prongs was a small ball (5 or 6^{mm} diam.) of good cork, suspended by a silk fibre. The images of the fork and of the cork ball were projected on a screen.

No. 3 had one prong weighted with wax, so that it gave two beats a second with No. 1 or 2.

No. 4 had the ends of its prongs filed off, until it also gave two beats per second with 1 or 2; thus No. 4 gave two vibrations a second more than No. 1, while fork No. 3 gave two vibrations a second less than No. 1.

The Experiments

In the experiments one to seven inclusive, fork No. 1 remains before the lantern, with the suspended cork ball just touching one of its prongs.

EXP. 1. Fork No. 2, screwed on its case, was held in the hand, at a distance of 30 to 60 ft. from No. 1, and sounded; the ball was projected from the prong of fork 1, which vibrated in unison with 2.

EXP. 2. I stationed myself 30 ft. distant from fork No. 1, and fork No. 2 was screwed off its case and vibrated in one hand, while the case was held in the other. I now walked rapidly toward fork 1, and after I was in regular motion I placed the fork on its case, and just before I ceased walking I took it off; although, when I did so, I was only about a foot from fork 1, yet the cork ball remained at rest against its prong.

EXP. 3. Again I walked toward 1, as in Exp. 2, but I did not remove the fork from its case after it was placed on it. The ball remained at rest until the moment I suddenly stopped walking; at that instant the ball flew from the fork, while an assistant, whose ear was close to the case of fork 1, while his eye was directed to the screen, found that at the instant I stopped walking, the fork 1 sounded, while the ball jumped from its prong.

EXPS. 4 and 5. These experiments were exactly like Exps. 2 and 3, except that I walked away from fork 1 instead of approaching it. The results were the same as in Exps. 2 and 3.

EXP. 6. Fork No. 3, giving 254 vibrations per second, was sounded as in Exp. 1. It had no effect in moving the ball. I now screwed the fork off its case, and, standing about 30 ft. from fork 1, with my arm I swung the case toward fork 1, and while it was approaching it I placed fork No. 3 on the case; the proper velocity (from eight to nine feet per second) having been obtained, the ball was suddenly projected from fork 1. On greatly increasing or decreasing the above velocity of the moving case, the vibrations of fork 3 produced no effect on fork 1.

EXP. 7. Fork No. 4, which gives two vibrations per second more than No. 1, was substituted in Exp. 6, but was placed on its swinging case when this was receding from fork 1. The effect of this motion and of varying velocities was the same as in Exp. 6.

EXP. 8. I placed fork 3 before the lantern, and swung fork 1 as in Exp. 7. The effects were the same as described in Exp. 7.

EXP. 9. I now placed fork 4 before the lantern, and moved fork 1 as in Exp. 6. The effect on the ball was the same as in Exp. 6.

By these simple experiments I have shown the change of wave-length produced by the translation of the vibrating body, and have given an experimental proof of the important theorem which Doppler established in 1841. By analogy they clearly unfold that exquisite modern method of determining the motions

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